

# The HANDI-Finder<sup>®</sup> Experimenter's Kit

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The **HANDI-Finder<sup>®</sup>** is a **HANdheld DIrection Finder** which can be used to localize both AM and FM sources using only a single connection to the antenna input of a VHF-FM receiver tuned to the frequency of interest.

The basic **HANDI-Finder<sup>®</sup>** when equipped with open-loop wire antennas and a short handle, stores flat and ready-for-use in a briefcase. It works well with just an HT (handy-talky).

The **HANDI-Finder<sup>®</sup>** has been designed for low power consumption, simplicity, and economy. The goal was to provide an easy-to-build kit for the beginner and a basis for further experimentation by those with more experience. Overall, it is a quick, inexpensive way to introduce users of FM communications equipment to the principle of direction finding and give them something with which they can help locate sources of malicious interference.

A **HANDI-Finder<sup>®</sup>** Experimenter's Kit has been put together to conveniently supply the essential parts necessary to build the control circuit powered by an on-board 9V battery. The user provides the coax, cable connector, and appropriate antennas. By using two open loop antennas made out of coat-hanger wire, the unit can be put into immediate use!

An equally valuable part of the kit is this instruction manual which describes variations in antennas, general construction and detailed discussions of the circuit and components, to encourage experimentation and ideas for improvements.

The **HANDI-Finder<sup>®</sup>** first came together in October of 1986, and continued to evolve. A write-up later appeared in May 1993 QST Magazine, entitled "Build the **HANDI-Finder**".

## TECHNICAL OVERVIEW:

The electronic circuit is based on a design credited to Tom Feierabend SO/CM 03N18 circa 1979 which appeared in a manual published in May, 1980 by Van Field, DCP XVIII, entitled "VHF Radio Direction Finding Manual for Coast Guard Auxiliary Use."

A similar circuit, referred to as the "Double-Ducky" direction finder (DDDF) designed by David Geiser, WA2ANU, is described in July 1981 QST and reprinted in the 1983 ARRL Antenna Handbook.

The USCG AUX-03N18 version uses an LM555 driving two successive stages of 7404 TTL to provide complementary buffered outputs. Since TTL requires a 5-volt power supply, yet another IC, a 7805 or 78L05 is needed, to regulate the stated 6-30 volt input range.

One problem is that the LM555 does not easily put out a symmetrical square waveform, which is needed in this application. The antenna assembly consists of two vertical 1/2-wave dipoles (37" long) mounted 8" apart on a

boom. This assembly is rather bulky and quite a bit of mechanical fabrication is required.

The QST circuit uses only one IC, the LM567 Phase-Locked-Loop Tone Decoder. This is a complex chip that contains an oscillator and other circuitry, including an output circuit, which does put out a symmetrical square wave. However it does not have simultaneous complementary outputs. In the DDDF the single output is connected to the diode switches through a non-polar capacitor, and some adjustment is required to achieve the proper switching level. Data sheet specifications show that the LM567C typically draws 12mA. The antenna assembly consists of two “rubber duckies” mounted 10” apart on a 4.25” X 18.5” ground-plane. While the ground plane requires much less work to fabricate than the USCG-AUX circuit, two “rubber duckies” must be obtained.

The HANDI-Finder<sup>®</sup> is a good example of integrated simplicity, wherein one simplification contributes to another.

First, it uses a single CD4047B CMOS IC, which contains both an oscillator and a divider flip-flop to automatically provide complementary symmetrical square wave outputs without special adjustments. Only a single resistor and capacitor are needed to set the frequency. *While many have not heard of this IC, it continues to be available from standard suppliers like Digi-Key, Mouser, and Jameco, since the early days of CMOS in the 1960's!*

Second, very little current is used to bias the switching diodes so the total current draw is only 1.7mA at 9V. Good service can therefore be provided by a common alkaline “transistor radio battery” and there is no need for wiring to an external source such as a 12V vehicular supply. This, in turn, eliminates the need for noise filtering. The operation of the circuit is not dependent on battery voltage, so a regulator is not required. Supply voltage for the CD4047 can be anywhere from 4-18 volts. Finally, since all the parts, including the battery are mounted on a single circuit board, the board is designed to also serve as the mounting base for the two open-loop antenna elements easily made out of bent wire. Thus, there are no ground-plane or vertical dipole elements to make, nor “rubber duckies” to buy, and no case to drill, until later if you really want to!

### **HOW IT WORKS:**

All three circuits described above are based on the same principle. An electronic switch alternately connects two antennas to the coax cable down-lead going to the antenna input of an FM radio receiver tuned to the frequency of interest. First one antenna is connected, then the other, etc., back and forth with equal intervals. This is done at an audio rate, well within the audio band pass of the receiver, and usually in the range of 400 to 1500 Hz. A good frequency is 1000Hz.

Of the two antennas, if one is slightly closer to the source, it receives the wave front slightly earlier in time

(phase) than the other. There is a phase difference in the signal received by one antenna compared to the other. Since the receiver is being switched between the two antennas, the switching action imposes phase modulation on the incoming signal. This is detected in the FM receiver and is heard at the audio output as a tone equal to the switching frequency. The *amplitude* of the audio signal corresponds to the *deviation*, which depends on the physical separation of the two antenna elements, up to a  $\frac{1}{2}$  wavelength. In other words, if the antennas are farther apart, within that  $\frac{1}{2}$  wavelength restriction, the circuit will impose a higher percentage of modulation or a larger deviation, producing a louder tone, but the modulating frequency will stay the same.

If the antenna is rotated so that the plane of the two elements is perpendicular or broadside to the direction of the signal, both elements receive the signal at the same time (phase) and there is no longer a difference in phase. Hence, the audio tone disappears. This is perceived as a rather sharp null in the audio tone modulation as the antenna array is rotated into position perpendicular to the direction of the signal.

This type of direction finder DOES have the disadvantage that it exhibits 180-degree ambiguity. However, it has several advantages:

- 1) It works on a nulling principle rather than a peaking principle. The null is sharp and much easier to detect than the peak

from a directional or beam antenna.

- 2) When you null the superimposed audio, you are not nulling the carrier. This is unlike a conventional loop antenna or cardioid array, which nulls out the carrier. The problem with carrier-null is that as you get closer to the null, the signal you are trying to hear in order to null out is getting harder to hear! With the HANDI-Finder<sup>®</sup> when you null the superimposed audio, you can still hear the audio coming from the source.
- 3) Since audio is being nulled, the operator does not have to watch a field-strength meter. He only needs to listen, which is something he can do while driving, riding a bike or walking and keep his eyes on the path!.
- 4) Since this method uses phase information, it works well with strong signals, so no attenuator is required. (By comparison, the signal from directional gain antennas must be progressively attenuated to keep the receiver RF within the range of the S-meter.)

## REFERENCE INFORMATION:

The HANDI-Finder<sup>®</sup> is an evolving project which underwent several changes (hopefully for the better) during the early stages. However, the basic circuit remains essentially the same. This web version of the manual can help you work on an earlier unit, as far back as 1986. If you have a model that does not correspond to the

pictorial description supplied with this document, you should be able to identify the components with only minimal tracing of the etched circuit pattern.

The specific manual supplied with your specific unit may have component values that differ from the original schematic. If you did not buy a kit, you may have obtained the circuit board and documentation from independent sources which make and distribute their own version of projects published by others, making only minor changes.

The circuit board versions are identified by a prefix letter "A", a 6-digit date-code (YYMMDD), and an optional suffix. (The suffix, if present, indicates very minor changes.) As of this writing, the numbers used are: A861003, A860102, A870122, A890422, A01110, A031123, A100523, A151121.

In general, if the board has a date code earlier than the documentation, the latest component values take precedence. If you need updated information please contact the author. Please indicate whether the RALTEC® or other trademark is present and we will help you figure it out. Try contacting the author at [ral@ralserve.net](mailto:ral@ralserve.net). (If you have trouble, you can also find the author's current snail mail and e-mail addresses through the Internet Ham-Call database for K8DTS.) For information, try the website **handi-finder.com** and references to sales information there.

## CHECKING THE COMPONENTS

If you received this instruction manual as part of a packaged kit along with the circuit board and loose components, unpack all the parts and check the quantities and values against the Component Parts List before you do anything else because some parts have the same value but different mounting positions and lead lengths. Before proceeding with actual construction, it is suggested that you read this manual to see if there are any changes you would rather incorporate right away. Then proceed with "ASSEMBLING THE KIT" which is located at the end of this discussion.

### NO PILOT LIGHT:

Considering that a small transistor radio draws about 10mA, it can be seen that the battery will last quite a while if the user remembers to turn it off. Unfortunately a pilot light would be self-defeating, since it would draw 5-10 times the current of the circuit itself!

How many times have you forgotten to turn off your HT? After a while you finally learn to double check. With the HANDI-Finder® it should even be a little easier, because you will probably be disconnecting it from your radio or otherwise storing it at the end of a "DF'ing" session. That action should help remind you to check that the switch is off. Better yet, remove the battery, or slide it down away from the snaps. That's why we have included a top grade battery holder in the bare board version.

## **ON-OFF SWITCH and STATUS INDICATOR:**

For models prior to A890422, here are a couple of things to help you tell OFF from ON in the absence of a pilot light. First, the “ON is UP” convention has been followed. This is fairly commonplace on most equipment. Second, you can make a “passive” indicator by using a dot of bright paint, for example, document correction fluid such as “whiteout”. Push the slider to the ON position; then paint a small dot on the lower part of the slider that is now exposed. Let the paint dry thoroughly so it doesn’t rub off. When you slide the switch to OFF, the painted part should be hidden; when ON, it should be visible. On Model A890422 and later, the switch has 3-positions: OFF is in the center, UP is for DF’ing, and DOWN is for straight receiving or Standby. (Notice the design date is embedded in this code as YYMMDD.)

## **ON-OFF SWITCH MECHANICAL VARIATION:**

There are a couple of subminiature slide switches available from “experimenter” sources such as Mouser and Digi-Key, but they differ slightly in the spacing and style of the connector pins. Circuit boards A861003 and A860102 used the CW Industries switch available from Digi-Key as SW103-ND.

Starting with circuit board A870122, the switch pads were made larger and the spacing changed to use the Mouser 10SM007 or 10SP001. The larger pads allow larger holes to be drilled to allow for the wider flat pins. If the switch you have does not go right in, do not

force it. Study the problem and carefully enlarge the holes only where necessary. A small modeling file is handy for this purpose. Don’t make the holes any larger than necessary, or you will have trouble bridging the gap and getting a good flow joint when soldering. When you do solder it into position, use ample solder and heat it enough so the solder surrounding each terminal flows evenly into a nice even form similar to an “indian teepee.” **A890422 and later used a DP3T switch with 6 pins, which will not fit the previous models, but gave us the ability to add the “standby” position, which has been very useful. See Parts List.**

## **BATTERY HOLDER:**

The 9-volt battery holder is fastened at one end by soldering the two terminal tabs that pass through the board. The other end of the frame can best be fastened by using 1/8” diameter “pop-rivets” from the top side so as not to obstruct the battery. Make sure the center clip rivets set into the clearance holes or enlarge them.

## **QUICK HANDLE:**

The bottom area of the circuit board contains an area where the handle is attached. The unit can be mounted on either a short handle or directly to a mast, whatever you desire. To get going quickly, take any convenient piece of wood or metal, lay the end against the board, mark the holes, drill them through the handle, and attach with screws. If you use a round handle, you will either have to make a flat cutout along one side, or cut a slot

in the end so that the board can slide in. A round handle is best. The most utilitarian handle is described next.

### **PAINT-ROLLER HANDLE:**

Find an inexpensive paint roller, but one with a handle, which is threaded for an extension pole. (Home supply stores sell them typically for \$1.39). Study how the handle is attached and determine the best way to remove it or otherwise adapt it so the HANDI-Finder® can be mounted on it.

Most of the handles available these days are plastic, force-fit directly to the metal roller rod. Use a hacksaw and cut off the roller assembly rod so that about 3" of rod is left protruding from the plastic handle. File the rod enough to have a flat area, center punch the hole locations, and then drill two holes to match up with the circuit board, and attach. The flat side should of course go against the board. If you have the tools, you can drill #36 holes and tap them for 6-32 screws.

Next, shop around for your a wood (not metal) paint roller extension pole, preferably the type that is made of 3 sections, which screw together. You will thus have a very flexible system. You can use the unit with just the handle alone, or screw on up to three lengths of additional "mast". You may even wish to obtain a second extension to have more lengths available. Be aware that some extension handles have different threads in the sections than they have at the roller end. In any

event, the pieces are easily stored when disassembled.

### **Do not use a metal extension pole!**

*(See WARNING about touching overhead wires!)*

### **HANDLE, CAUTIONARY NOTE:**

Mount the handle against the component side and put the screws through with the heads on the solder side, to keep a low profile for the coax cable, which will come down the *center* of solder side, right over the other soldered pads.

The HANDI-Finder® works best when the first ¼ wavelength of coaxial cable downlead to the receiver is kept vertical or parallel to the center line of the circuit board. (Measure the ¼-wave from the bottom antenna terminal.) If it waves around, it can throw off the bearing. Therefore, when using the unit with a short handle, make sure to hold it straight and high so that the cable hangs straight down. When using the unit with a long handle it is preferable to attach the coax to the mast for the first ¼ wavelength. Use tape, nylon cable ties, etc.

***Do NOT raise the HANDI-Finder high up where it can come in contact with any overhead wires!***

### **RESISTORS vs. INDUCTORS:**

The HANDI-Finder® was designed mainly out of the need to inexpensively provide Radio Amateurs with

something they could use to help locate interference on the 2-meter repeaters. But the unit operates over a much wider range of frequencies because the chokes “traditionally” used in such RF circuits have been replaced by resistors.

Inductors are usually used to feed direct current into some point in a circuit where it is desired to allow an alternating current signal to pass without attenuation. At radio frequencies these are called “RF chokes”. Circuits that operate in the 150MHz range, for example, usually use small coils with a value of 1.0 to 1.2 microHenries.

Using the expression  $X_c = 2(3.14)fL$ , where “f” is the frequency in MHz and L is the inductance in microHenries, the corresponding reactance works out to about 1000 Ohms. At 1/3 the frequency, or 50 MHz, this same inductor would have a reactance of only 333 Ohms. At UHF this inductance would mathematically exhibit a proportionately higher reactance, but other difficulties arise. Certain assumptions about the construction of the coil are no longer valid and the math becomes more complicated. Factors like the “capacitance between turns” and the length of the connecting leads can no longer be ignored. At some frequencies the coil looks like high impedance, but at others it may look like a short circuit! Stray capacitances can cause it to have undesired resonances.

Thus, the frequency band over which the circuit can operate is limited by the

chokes. Different sets have to be installed to operate over different ranges of frequencies. Normally it is necessary to use chokes because they have a comparatively low resistance at d.c. so there won’t be any significant voltage drop. The key word here is “significant”.

In this circuit, the switching diodes are biased by current. As long as enough current is supplied to do the job, it doesn’t matter if a little voltage drop occurs across the connecting element. 1000-Ohm resistors can simply replace the chokes. The currents are so small that the voltage drop is negligible. Further, for all the complications involved with determining how chokes will act at different frequencies, it is no less risky, and a great deal easier, to assume that a resistor will exhibit the same resistance over a much wider frequency range.

In this circuit R4, R5, and R6 would have “traditionally” been specified as 1.0 $\mu$ H chokes for operation in the 150 MHz region. As you can see, by using 1K resistors, operation at 150 MHz should not be affected, and operation over a wider range of frequencies should now be possible. The value of the resistors is not that critical. Values in the range of 1K-1.3K will do, but make them all the same style and value. Using carbon-film resistors, we also get some useful inductance, but since the resistance is high and distributed with resistance, these are inherently free of self resonance, and broadband because they are low Q.

However, if you wish to experiment with inductors, you can either make

them or buy them. According to the USCG AUX article, you can make these with one layer of #28 close wound on a 1 Meg ½-watt carbon composition resistor. Actually there is nothing magical about the 1 MegOhm value, it is the physical size and shape that is more important. The intention is that the resistance be at least a factor of 100 times greater than the inductive reactance. Therefore any value above 100k is acceptable.

Mouser Electronics once had a line of good quality subminiature RF chokes that are quite reasonably priced, roughly \$.23 each. Shown as the Miller “43LQ” series. The 1µH value was part number 43LQ106. A more present-day equivalent is now 871-1378108E1102K009. Keep in mind they probably will not fit on the HANDI-Finder circuit board supplied with the kit.

### **WIDEBAND OPERATION:**

The HANDI-Finder<sup>®</sup> should work over a wider range when resistors are used in place of inductors, but there will still be problems with resonance (series LC) and anti-resonance (parallel LC) for any given set of antennas. However, ignoring those effects, let us discuss the effect of antenna spacing. Remember, you want the vertical members of the two antennas as far apart as practical to get maximum modulation.

This will make it easier to tune for a null.

For a given set of antennas, the upper frequency limit should be that which corresponds to a ½ wavelength equal to

the widest spacing of the vertical members.

If the usual wavelength formula is multiplied by 12 inches/ft, a new “constant” factor is obtained: dividing 5616 by the frequency in MHz will give the ½ wavelength in inches. For the open-loop antennas you will be instructed to make elsewhere in this manual, the spacing between opposing vertical sections is typically 17.5 inches. Turning our formula around and dividing 5616 by 17.5 gives 321 MHz, which is also the frequency at which maximum deviation would be available. Some have reported operation to include the 70cm Ham Band. Conversely, dividing by some upper limit of 600MHz gives 9.76 inches. Try to make the vertical part of the bow-tie and ¼ wave at the frequency on interest.

Moving to 1/10 that frequency or 32 MHz, *only 1/10 the modulation would be available*, but the units should still function. So it would appear that operation over a 10:1 range might be possible.

### **COUPLING CAPACITORS:**

At the lowest limit, it is important that the coupling capacitors have a reactance of 50 Ohms or less so as not to attenuate the signal by more than 3dB. If we choose that limit to be 27MHz the value of capacitance having 50-Ohm reactance is 117pF. Values of .001µF, or 1000pf will be one tenth that or 5 Ohms, and work just fine.

## SCREW TERMINALS:

Antenna connections to the board are made using screw terminals. On early units, these are formed by installing a clip-type “tinnerman nut” which is slipped onto the circuit board edge at each designated point then threading in a 6-32 x 3/8” or 1/2” binder head machine screw. Only four are needed for any given configuration. Later units use regular hex nuts, serrated lock washers, and flat washers against the board to keep the lock washers from tearing up the copper foil.

When fastening small diameter or stranded wires to these, it is suggested that you first install crimp-on spade lugs or ring lugs on the end of the wire. If you must wrap the wire around the screw, do it under a washer and wrap it in the direction that the screw tightens (clockwise).

**BE CAREFUL NOT TO OVERTIGHTEN.** If you experiment a lot, the Tinnerman nuts will strip and wear out. If you need to have things very tight, you can use 6-32 screws with regular hex nuts. *However, do not put serrated lock washers against the surface of the board since they really dig in and cause problems.* It is better to use a slightly longer screw with flat washers to protect the surfaces. If you are tempted to just solder directly to the board, don’t do it! The heavy heat may cause the foil to de-laminate. Further, if the antennas are bumped, the foil may be pulled off the board. If you want to have some sort of “rounded off” nut on the thread end, inquire about “acorn nuts” in the screw specialty section of most hardware stores. Make sure the flat of the

antenna terminal actually presses against the board eyelet.

## ANTENNAS:

The HANDI-Finder<sup>®</sup> is quite versatile in the way it can be used with different kinds of antennas. First of all, you can get it running immediately without extensive fabrication because two simple wire antennas can be attached directly at the circuit board. For 150 MHz, take two EQUAL lengths of stiff wire about 19 to 20 inches long and bend each one into a neat square “U” shape. The bottom of the “U” should be about 6”. Form the ends into a hook and fasten them to the screw terminals on the circuit board. Looking at the component side of the board, you will see there are three terminals along the left side and three along the right side. Fasten one end of one antenna to the very top terminal on the right side. Fasten the other end of that same antenna to very bottom terminal on the same side. Then repeat this procedure for the left side. (See pictures.)

*Note that the bottom terminals are merely mounting points. They are electrically isolated.* On some board designs there are circuit pads to allow installation of a grounding jumper. **DO NOT INSTALL THIS JUMPER!** It is desired that the antennas be open loops. If you ground the bottom of the loop, you will create a closed loop that will cause a carrier null in the direction of the signal. This is not desirable. On later circuit boards provisions for grounding was eliminated to avoid confusion. The wire you use should be thick enough to provide desired rigidity, but thin enough to allow

fastening under the screw terminals. If it is too thick, you might be better to first solder on some spade lugs or similar term-inations. Of course, it helps if the wire is a good conductor, but steel coat-hanger wire or welding rod will work satisfactorily. A better choice would be brass rod or brazing rod, between 1/16" to 3/32" thick. If you wish, you can make the loops even larger.

*Note the ACTIVE ELEMENT of each antenna in this application is the vertical part of the open loop supported in space by the horizontal part. A greater separation of the vertical elements will produce a larger deviation and more audio. However, the longer a vertical element is, the more signal it will receive, provided there isn't some gross impedance mismatch. This shows up as more carrier, better quieting, or a stronger S-meter reading. Of course, when that vertical section is maintained in space by an unshielded horizontal section, determining the resonance or tuning gets very complicated. Also consider that the horizontal part does receive some signal, and this degrades the intended signal. **Therefore, larger open loops may work worse. Feel free to experiment; that is the whole object of this project!***

Alternatively, the circuit board is designed to accommodate connections by coax cable to other kinds of antenna arrays. *Just below the top antenna mounting screw on each side, is a ground screw. This is not used with the open loop antennas, but is used for the coax shield.* Thus, if you do wish to make a "Double-Ducky" direction

finder as described in the ARRL Antenna Handbook, you can connect the two equal-length coax cables to the HANDI-Finder<sup>®</sup> circuit board. Similarly, you can fabricate the dual half-wave vertical dipole array described in the Coast Guard Auxiliary Manual and run it with the HANDI-Finder<sup>®</sup> board.

One suggestion for a more extravagant system is to position two multi-element Yagi antennas with vertical orientation at opposite ends of a horizontal boom. Support the boom at its center on a vertical mast so that it can be rotated. Use equal lengths of coax from each beam and connect them to the HANDI-Finder<sup>®</sup> board which should be mounted in a protective enclosure at the center of the boom. The beams will give greater forward gain and reduce the 180-degree ambiguity. It is just a little hard to use with the mobile!

### **Caution! -- Safety First!**

*With the basic HANDI-Finder, and the versions with added and extravagant antennas, always be mindful of the surrounding hazards.*

**Do NOT raise the HANDI-Finder up where can hook or snag anything, or come in contact with any overhead wires!**

**Also do not use this or any overhead antenna in cloudy conditions where lightning might strike!**

## **NO ENCLOSURE:**

As you can now appreciate from these discussions, there are many ways you may end up using the circuit board and enclose it accordingly.

In its simplest “quick & dirty” constructed form, the unit can be put to immediate use. The long narrow profile was selected to minimize wind resistance if it is used in a windy situation such as on a boat. ***Do not hold it out a window while driving a vehicle!***

You will discover that an enclosure will only increase the drag and may not be worth the effort! With only minimal care, these units have rattled around in many trunks and back seats without anything getting shorted out. The battery in one of the demo lasted over three years, even though it had been left “ON” for several weekends during that time!

However, you might want to consider that numerous sharp edges from component leads could snag cloth upholstery, or scratch leather and vinyl.

Where you really need to, the circuit board can be mounted to surfaces on standoffs using 6-32 screws through existing holes.

## **MOUNTING IN AN ENCLOSURE:**

Model A890422 and later are designed so that it can be more easily modified to fit into a case. This is somewhat irreversible since it requires that the bottom part of the board be cut off, unless you can find a really long, flat plastic case. Some have come and gone off the market, so it is there is no

particular model case that can be recommended. It is strongly suggested that the circuit be completely built up on the existing board and thoroughly checked out. After you are familiar with the unit’s operation and shortcomings as well, you may NOT wish to put it in a case.

## **TRYING IT OUT:**

It is best to start off with a “test” situation where you know the location of the source, and experiment with “getting a feel” for the null. The null itself is fairly sharp, but it does not always manifest itself as a total null in the audio tone. Sometimes, you will observe instead, a jump in tone one octave up or down. (Refer to the ARRL Antenna Handbook article for more discussion.) *Many hams use the weather stations transmitting in the 160MHz band as a test source. Most HTs receive these frequencies now.*

At other times, you may hear a “buzz” or a fast “twiddle”. This is usually due to multipath, so moving just a few feet may help clear up the null. Also, if there is a strong transmitter in the area, such as a 1kW paging system, 3 or 4 MHz away, you may experience more “de-sense” than normal when the HANDI-Finder<sup>®</sup> is switched on in the DF-ing mode. The sharp edges of the diode switching waveform cause it to be rich in harmonics, all of which modulate that strong RF source and cause it to broaden its normal spectrum at the input of your receiver. (These are the same problems that bother the more complex “DOPSCANS” that switch 4 or 8 antennas.)

Using the unit with a synthesized scanner or one of the new extended-coverage HT's will not only allow you to work in the Ham bands, but other frequencies as well. The prototypes were tried over the range of 49 MHz to 450 MHz and worked well even though the 450 MHz test was well above the suspected  $\frac{1}{2}$ -wave limit frequency of 321 MHz calculated previously. As you get considerably above or below the 150 MHz design frequency you may find that your unit has a "null" point which is no longer perpendicular to the plane of the circuit board. However this also sometimes occurs due to multi-path in high reflection areas, especially indoors. ***(Don't try to do anything meaningful indoors!)*** In any event, don't jump to conclusions. Take several measurements at different locations a few feet apart, and consider your findings carefully before deciding whether the problem is due to the location or a characteristic of the way you have set up your particular unit.

***Multipath occurs everywhere and is the downfall of all direction finding systems. It really is very difficult to get good bearings if there are any buildings or large objects, towers, etc anywhere for hundreds of feet. But that is what makes it all interesting if someone hides on purpose as the "fox" and you try to find them. You take several bearings at twenty foot intervals and none of them seem to make any sense. It can be very frustrating! About the only place that things start to work for you is maybe on a lake, or in a very flat area!***

When driving through neighborhoods it is interesting to scan the bands and see what frequencies are in use. For example, one of our experimenters found several homes with 49 MHz "baby monitor" intercoms. You may also hear some old cordless phones near that frequency. These are fairly obsolete now.

Another application is to drive around and look for Cable-TV leakage on 145.250 MHz. You will quite easily pinpoint hotspots on poles and at the lawn boxes used for underground installations.

If you are an avid radio-controlled model airplane enthusiast, and have had a plane get lost in the woods, this could save you time. Put a low-power transmitter and "crash switch" in your plane. Then if it gets away or crashes in the woods, you can track it down!

Some areas have rather extensive park reserves or other situations where naturalists "tag" wild animals with radio transmitters to track their migration.

They are quite interested in reports on these animals, and will give out the frequencies to individuals with a genuine interest in helping. Invite your local naturalist to speak to your club and demonstrate how you can help. But keep in mind they DO NOT put radio collars on deer and turkey just to make it easy for game hunters to track and kill them!

#### **DIRECTION CALIBRATION:**

A round handle is best, because it allows a calibration mark at any angle. You would do well to try your unit

outdoors in an open field by walking in a circle around a central source. Please do not key up a repeater repeatedly just to have a source! A helper keying an HT held up at arm's reach is easiest, but needs to hold still. The null should always occur perpendicular to the plane of the antennas, but your radio or other factors such as reflections off buildings (or even people) may be introducing phase shift. If the error is totally consistent as you walk around the circle, then you will want to mark the true direction on the handle.

If such is the case, expect this calibration to change at different RF frequencies, or if you change the CD4047 oscillator frequency. If the error is not consistent, and changes as you walk around the source, you are experiencing (multi-path) reflections from the surroundings. Try reducing the power of the source. For example, if a 100 mW HT is too strong, remove the antenna and substitute a 51 Ohm, 2 watt carbon resistor. If you still get erratic readings you will have to go to another location.

Once you have established the calibration mark, fasten the cable along the side of the handle or mast so it runs over the mark. That way you can feel it in the dark. Now you are ready to do some serious DF-ing or Fox Hunting.

Notes:

1. Bob Leskovec, K8DTS, has been licensed since 1957 and promises not to change his call letters so you can always locate his mailing address via the Ham database!
2. A less detailed description of this project appeared as "Build the HANDI-Finder!" QST Magazine, May, 1993.

3. HANDI-Finder<sup>®</sup>, RALTEC<sup>®</sup>, are Registered Trademarks which must always be acknowledged as such, and never used as "generic" references.
4. Latest info is posted at the website [HANDI-Finder.com](http://HANDI-Finder.com)

## The HANDI-Finder<sup>®</sup> Experimenter's Kit

### ASSEMBLING THE KIT: (Please read the whole manual before assembling)

- 1) Check the circuit board and make sure all the holes are drilled and it is otherwise finished and ready to accept the parts.
- 2) Having read the discussions about the ON/OFF switch, locate that item and make sure that the type you have does indeed fit the hole pattern on the circuit board. On Series A151121 it has been pre-installed, due to a hole-spacing error corrected in later versions.
- 3) Locate the integrated circuit socket, carefully straighten the pins, and insert it onto the component side of the board with the proper orientation. You may have to study the IC socket to determine how its design denotes the position of pin 1. Some sockets have a beveled corner at pin 1. Others have an indentation at the end between pins 1 & 14, some are not clearly labeled!

*Note, for packing purposes, the IC may have been installed in the socket.* It is NOT necessary to remove it, unless you can see it has been inserted

in the socket incorrectly. The IC will incur much less handling and there will be less chance of damaging it if you just leave it in place when you solder the socket onto the board. Make sure the socket is properly oriented and seated flat against the board when you do the final soldering.

4) In the following order, mount the diodes, resistors, and capacitors, starting with the smallest parts first. If you have only one capacitor with long leads, SAVE that, and use the precut ones first. On some boards there is one location that needs the capacitor to be formed with longer leads. Also, **DO NOT FORGET TO INSTALL THE JUMPER MARKED ON THE BOARD**

5) Examine the ON/OFF switch and make sure that the terminals are clean and not tarnished, before soldering. If needed, carefully scrape them with a small hobby blade. Then mount the switch and solder it in position. The 6-pin switch also requires that four corner frame tabs be soldered as well. **NOTE:** if you later use a solvent to remove flux from the board, be especially careful not to get any into the switch. Some plastic parts melt.

6) Refer back to the discussion about the battery holder and mount that item.

7) Prepare the end of a length of RG-58/U or the miniature RG-174/U and attach it to the board. Note that the hole for the shield is large so that the shield can fit through. The excess braid is cut off so that only about 3/16" lies flat against the circuit foil where it is soldered down. Install a nylon cable

tie through the holes provided in the circuit board. Pull it tight so that it anchors the coax securely against the board to prevent flexing at the cable end. This is known as a "strain relief." Clip off the excess. (On old board designs, depending on what type of handle you use, you will need to figure out how to route the coax so that it crosses to the center and comes down the handle equidistant from the two antennas for best symmetry.) Later circuit board layouts have the coax routed down the center line on the solder side of the board on the side opposite where the handles should be attached.)

8) Fashion two open-loop antennas according to the instructions described previously and attach them to the board using the 6-32 screw hardware. One way is to put the screws in so the heads are against the bare foil side, so the heads make contact with the foil.

Put the serrated lock washer between a washer and the nut and never against the board foil because it will dig in and chew it up. If you put the screws from the top, then washers should be against the foil pad. **NOTE: The washers are made by stamping, and can be slightly "concave". When tightened, the center may not touch the antenna pad. Check continuity. Mount the washer with the "convex" side against the antenna pad!**